User Guide for

# FEBSPM7_M02MTCA

# Evaluation Board

## Motion SPM®7 Series

## Featured Fairchild Products:

## FSB70250

## FSB70450

## FSB70550

## FSB70325

## FSB70625

***Direct questions or comments about this evaluation board to: "Worldwide Direct Support"***

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# 1. Introduction

This user guide supports the evaluation kit for the Motion SPM®7 Series. It should be used in conjunction with the Motion SPM®7 datasheets as well as Fairchild's application notes and technical support team. Please visit Fairchild's website at www.fairchildsemi.com.

## 1.1. Description

Fairchild's Motion SPM®7 Series provides efficient motor control for energy restricted small power inverter driven application when space is constrained, such as circulation pump, compact fan.

Motion SPM®7 series integrates six fast-recovery MOSFETs (FRFET®) and one three-phase High Voltage ICs (HVIC). Motion SPM®7 series reduces board space by utilizing an ultra-compact 12.9 mm x 12.9 mm package and by incorporating built-in HVIC that provide single supply MOSFET gate driving capability. The Motion SPM®7 series offers designers high reliability with integrated Under-Voltage Lockout (UVLO), Thermal Sensing Function (VTS) and Over-Current Protection (OCP).

## 1.2. Features

- 250 V/ 500 V 3-phase FRFET Inverter Including HVIC
- Max. $R_{DS(ON)}$ - FSB70250: 3.4 Ω; FSB70450: 2.2 Ω; FSB70550:1.85 Ω, FSB70325: 1.4 Ω; FSB70625: 0.8 Ω
- Separate Open-Source Pins from Low-Side MOSFETs for Three-Phase Current-Sensing
- Active-HIGH Interface, Works with 3.3 / 5 V Logic Schmitt-Trigger Input
- Optimized for Low Electromagnetic Interference
- HVIC Temperature-Sensing Built-In for Temperature Monitoring
- HVIC for Gate Driving with Under-Voltage Protection and Interlock Function
- Isolation Rating: 1500 $V_{RMS}$ / Minimum
- Moisture Sensitive Level (MSL) 3
- RoHS Compliant

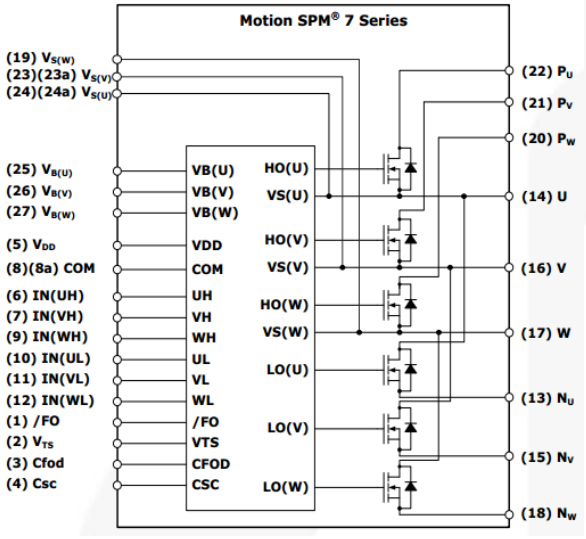



**Figure 1. Block Diagram**

# 2. Evaluation Board Specifications

All data for this table was measured at an ambient temperature of 25°C.

**Table 1. Summary of Features and Performance**

| Description | Symbol | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Positive DC Bus Link Input | V_dcb[1] | 120 | | 375 | V |
| | V_dcb[2] | 120 | | 250 | |
| DC voltage Output | $V_{15}$ | | 15 | | V |
| Logic 1 input | $V_{IH}$ | 2.4 | | | V |
| Logic 0 input | $V_{IL}$ | | | 0.8 | V |
| Fault Output | /Fo | 0 | | 15 | V |
| Analog Output Range | $V_{sig_a}$[3] | 0 | | 5 | V |
| Bus Voltage Sensing | $V_{s_dcb}$ | | 8.4 | | mV/V |
| Phase Current Sensing | | | 47 | | mV/A |
| Dead Time | $t_{dead}$ | 500 | | | ns |
| PWM Switching Frequency | $t_{PWM}$ | | 15 | | kHz |
| Temperature Sensing | $V_{ts}$ [4] | | 19 | | mV/°C |

**Notes:**

1. FSB70250, FSB70450 and FSB70550.
2. FSB70325 and FSB70625.
3. Analog Outputs include: three phase current sensing is_U, is_V, is_W; Temperature Sensing $V_{ts}$, Bus Voltage Sensing $V_{s_dcb}$.
4. Temperature of SPM®7 Module, for more detail, please refer to the corresponding SPM®7 data sheet.

# 3. Photographs

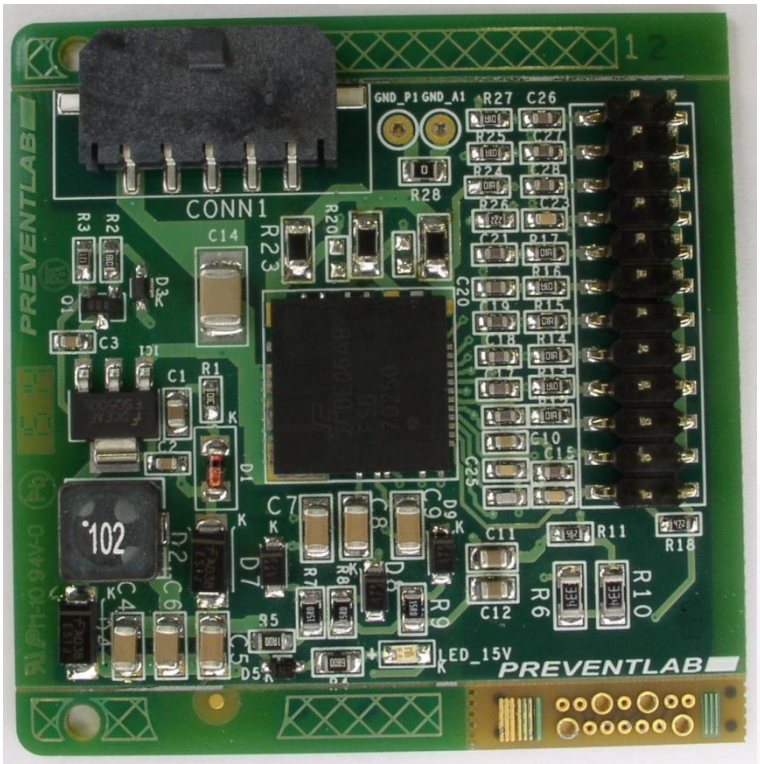



**Figure 2. Photograph (54.7 x 55.1 mm$^2$) Top View**

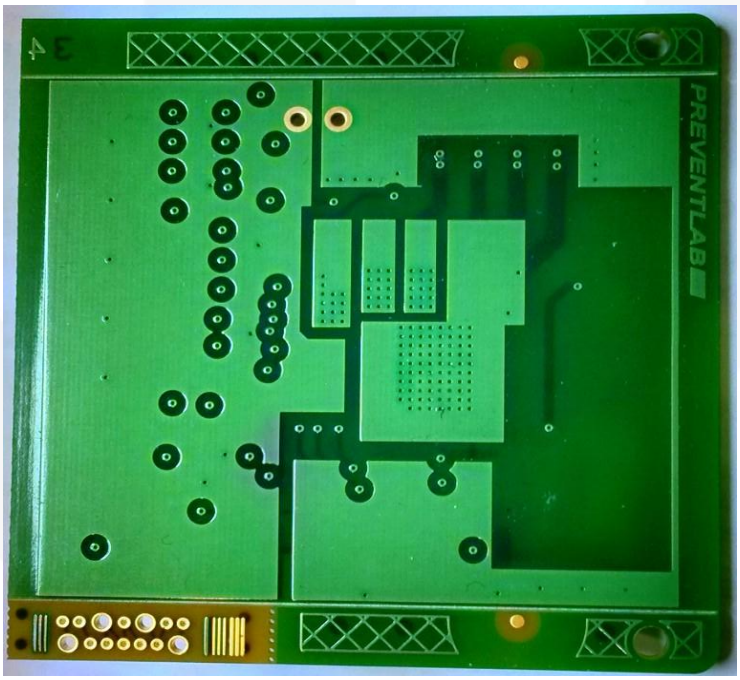



**Figure 3. Photograph (54.7 x 55.1 mm$^2$) Bottom View**

# 4. Printed Circuit Board

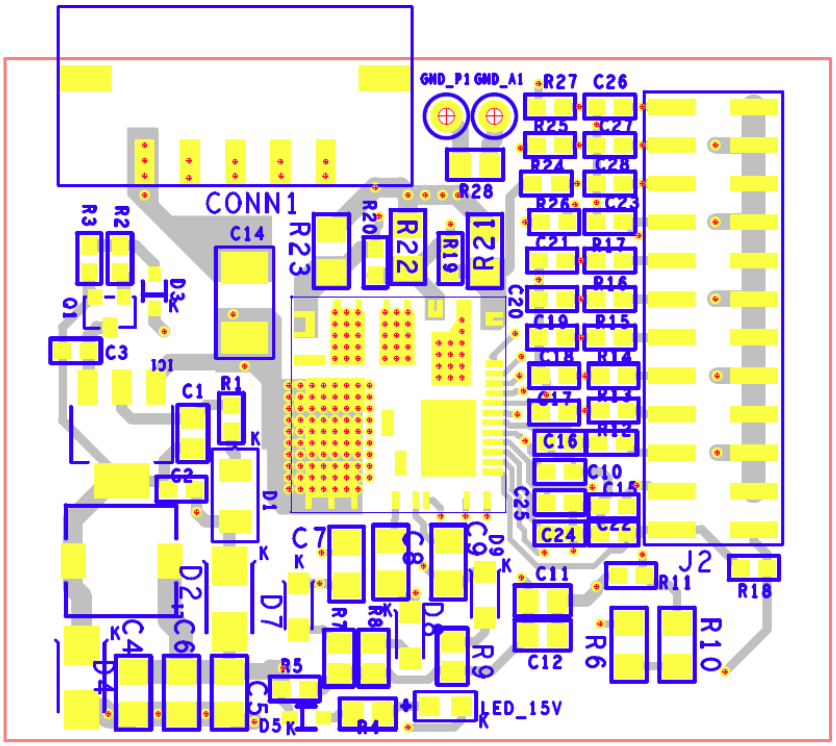



**Figure 4. Top Side**

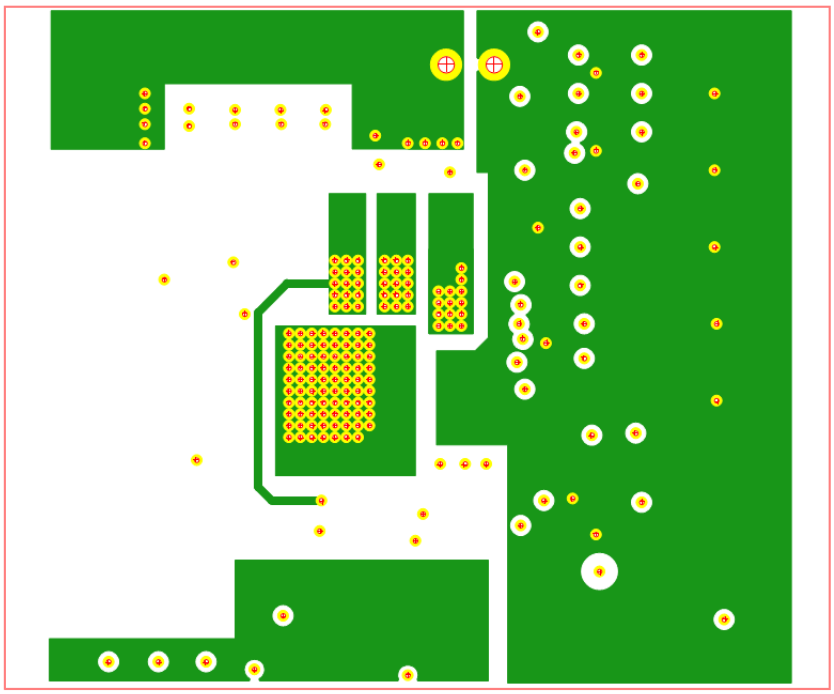


**Figure 5. Inner layer 1**

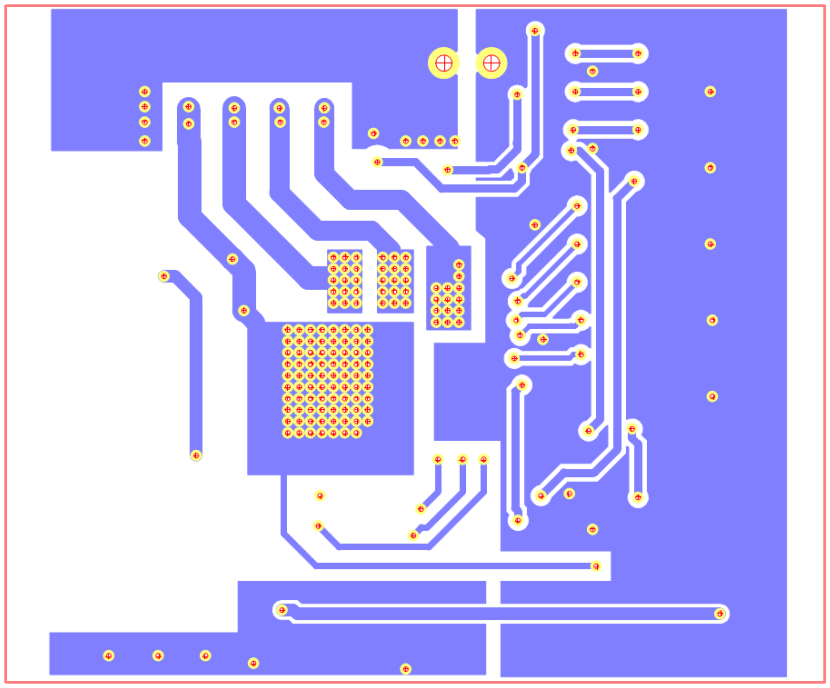


**Figure 6. Inner layer 2**

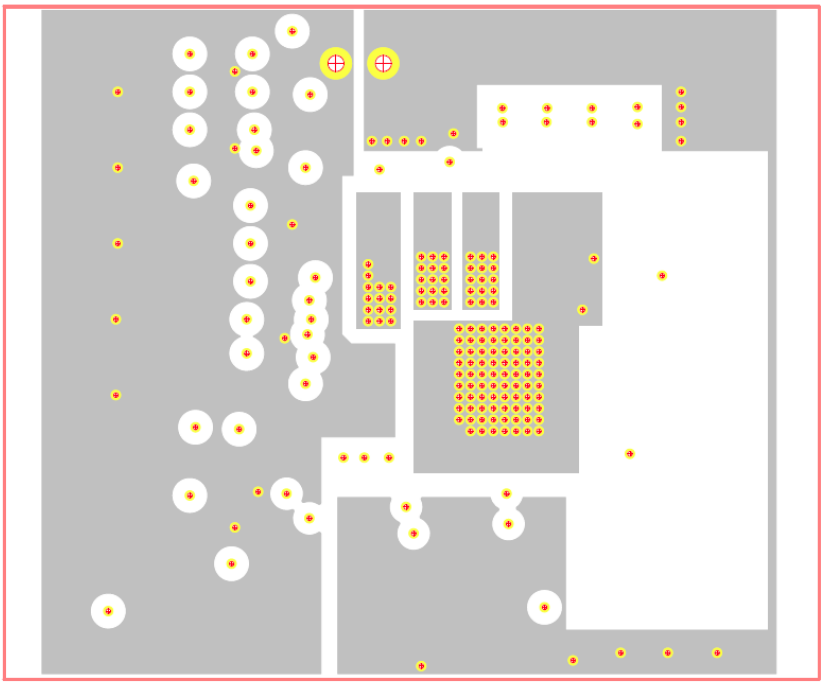


**Figure 7. Bottom Side**

## 4.1. External Connection

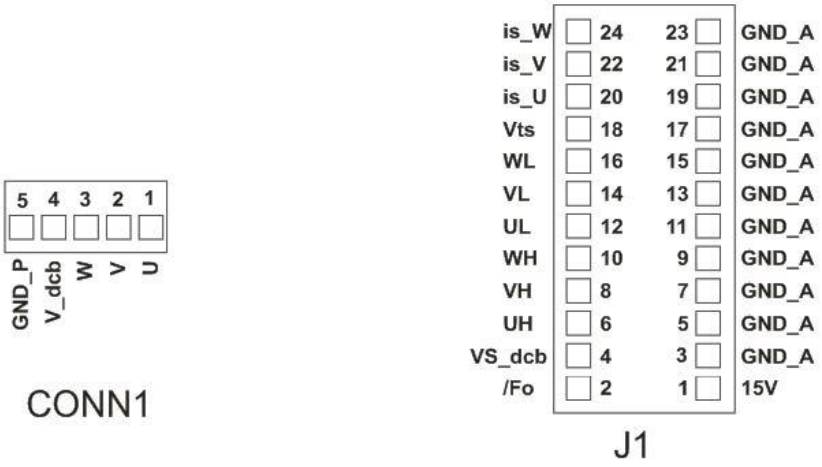



**Figure 8. CONN1 and J1 Connector Physical View**

**Table 2. Connector J1:**

| Pin# | Signal Name | Description |
|---|---|---|
| 1 | 15 V | +15 V Out of Internal Power Supply, Supply Max. 50 mA to the External. |
| 2 | /Fo | Fault Output |
| 4 | VS_dcb | DC-bus Voltage Sensing |
| 6 | UH | Gate Signal for High-Side Phase U |
| 8 | VH | Gate Signal for High-Side Phase V |
| 10 | WH | Gate Signal for High-Side Phase W |
| 12 | UL | Gate Signal for Low-Side Phase U |
| 14 | VL | Gate Signal for Low-Side Phase V |
| 16 | WL | Gate Signal for Low-Side Phase W |
| 18 | Vts | Voltage Output of HVIC Temperature |
| 20 | is_U | Current Sensing Phase U |
| 22 | is_V | Current Sensing Phase V |
| 24 | is_W | Current Sensing Phase W |
| others | GND_A | Analog Ground |

**Table 3. Connector CONN1:**

| Pin# | Signal Name | Description |
|---|---|---|
| 1 | U | Motor Connection (Phase U) |
| 2 | V | Motor Connection (Phase V) |
| 3 | W | Motor Connection (Phase W) |
| 4 | V_dcb | Positive DC Bus Link Input |
| 5 | GND_P | Power Ground |

# 5. Schematic

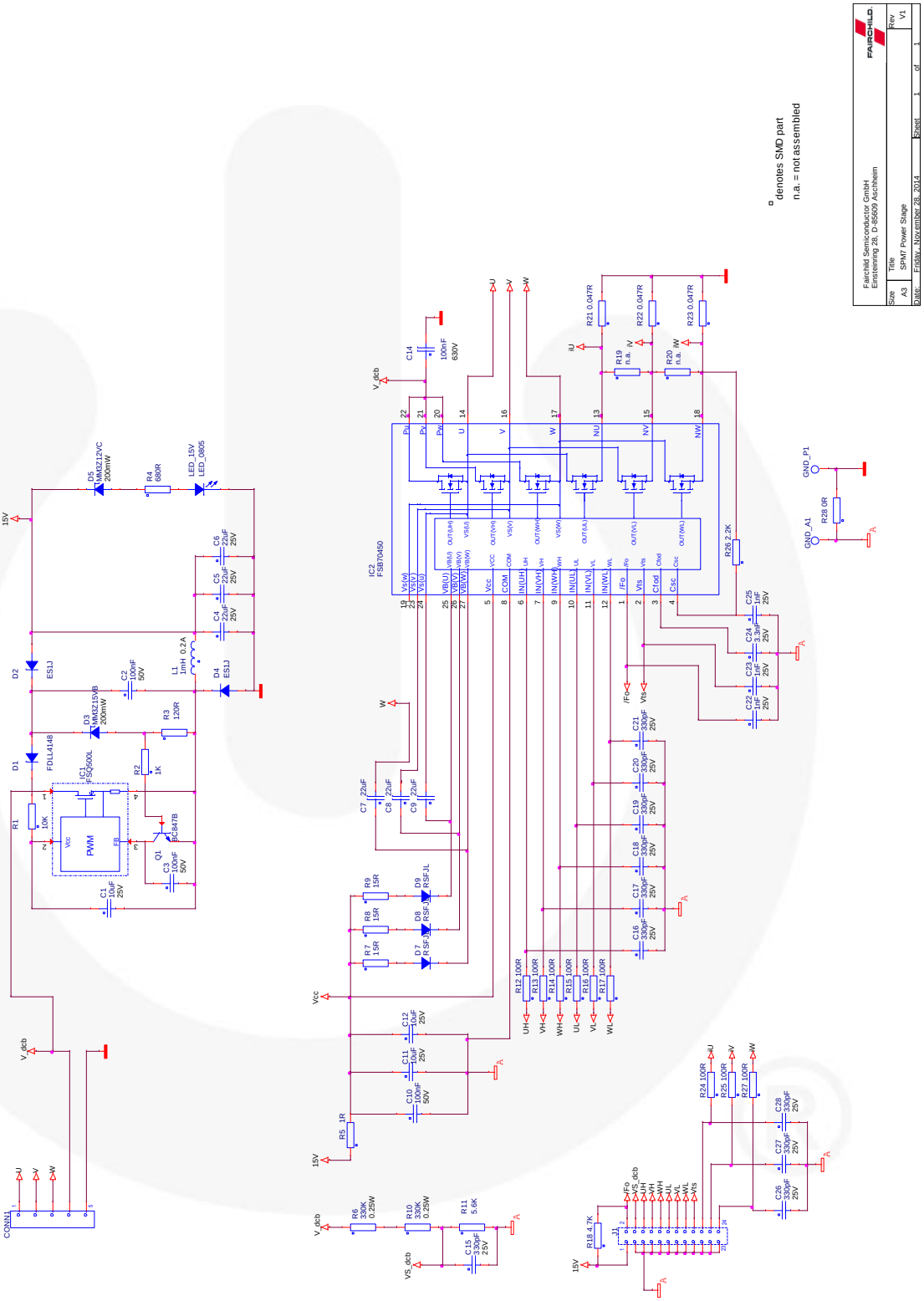



**Figure 9. Evaluation Board Schematic**

## 5.1. Circuit Description

Motion SPM®7 series is used as a highly integrated power module in this evaluation board to realize an Inverter for Low Power BLDC or PMSM 3-phase motors.

The board need to be supplied on the DC-Bus with a DC-voltage specified prior. The auxiliary-power-supply works as Buck-Converter and offers a stabilized 15 V to operate the module. The voltage is also accessible on the connectors to supply a Microcontroller-board if necessary. A LED indicates the presence of 15 V.

On the same connector of the DC-Bus, a motor can be connected to the Inverter output terminals U, V, W.

The internal High-Side-Drivers of SPM®7 need bootstrap circuit which consists of bootstrap capacitor, charge resistor and a fast diode.

The Shunts can be configured as 3-Shunt-sensing or single-Shunt-sensing.

Short-circuit protection is routed to just the W-phase and works in single-Shunt-sensing for the complete module. In 3-Shunt-sensing, only W-phase is protected. A low-pass Filter on Current-sensing avoids sensing of HF-peaks. The signal of fault output pin /FO drops from high level to low when a fault, such as Under-Voltage (UV) or Short-circuit Current (SC), occurs. A pull-up resistor and filter capacitor are added to generate a signal out of the open-drain output.

RC low pass filters are used between input connector from a MCU (or DSP) and Logic-input signal pins of Motion SPM®7 series to suppress any occurring disturbances. All Analog-Signals are filtered to provide smooth signals on the pins.

# 6. Thermal performance

### Test Condition

**Table 4. Test Condition**

| | |
|---|---|
| **Module** | FSB70450 |
| **Power Supply Voltage** | 325 $V_{DC}$ |
| **Motor Speed** | 500 rpm |
| **Motor Runs for** | 15 min |
| **Ambient Temperature** | 25°C |

**Table 5. BLDC Motor**

| | |
|---|---|
| **Series Number** | MATTKE BGK 65-40 NV |
| **Back EMF Constant** | 37 V/1000$min^{-1}$ |
| **Winding** | Delta |
| **# of Pole Pairs** | 4 |

## 6.1. Thermal Photo (without Heatsink)

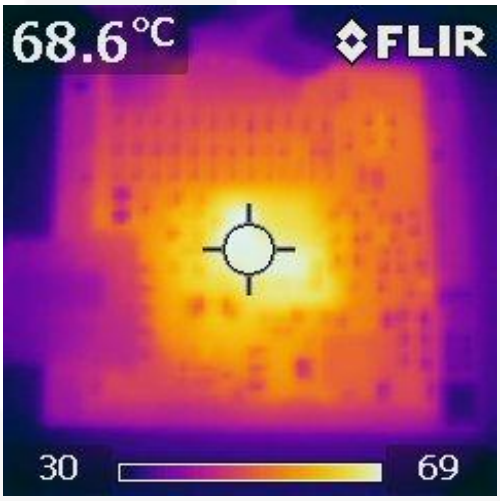



**Figure 10. Motor Power 60 W, Motor RMS Current 200 mA (without Heatsink), $T_{module}$ = 68.6°C**

## 6.2. Thermal Photos (with a Heatsink of 6.5 Kelvin/W Mounted on Bottom Side)

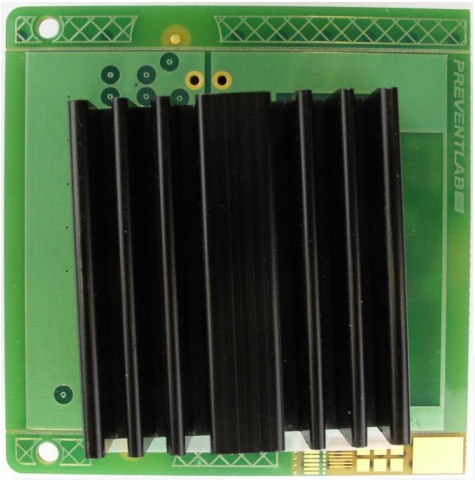
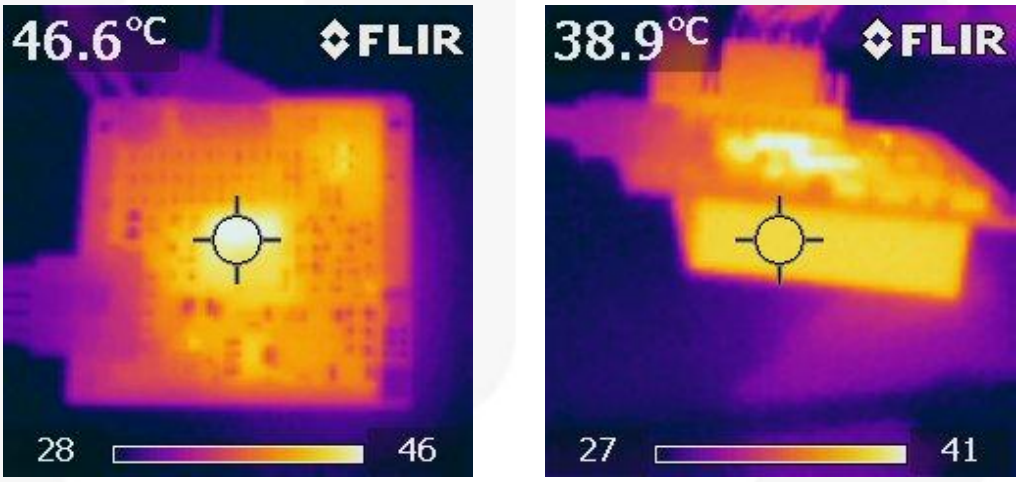
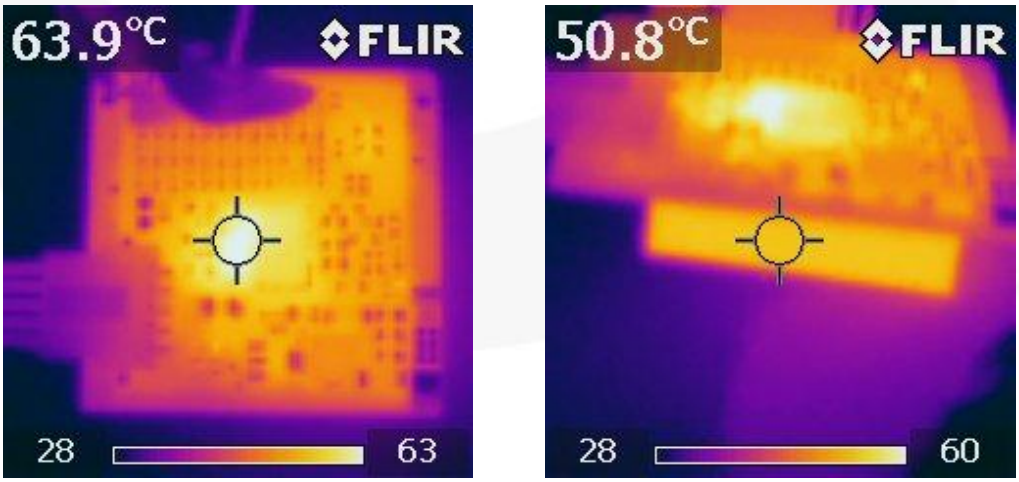


**Figure 11. Heatsink of 6.5 Kelvin/W on Bottom Side**




$T_{module}$ = 46.6 °C $T_{heatsink}$ = 38.9 °C

**Figure 12. Thermal Photos of Motor Power 60 W, Motor RMS Current 200 mA**




$T_{module}$ = 63.9 °C $T_{heatsink}$ = 50.8 °C

**Figure 13. Thermal Photos of Motor Power 120W, Motor RMS Current 400 mA**

# 7. Bill of Materials

| Item | Quantity | Reference | Part | Manufacturer/Series |
|---|---|---|---|---|
| 1 | 1 | CONN1 | Header_5pin_3mm_SMD_male | Wurth / WR-MPC3 |
| 2 | 3 | C1, C11, C12 | 10 µF / 25 V | any SMD 0805 |
| 3 | 3 | C2, C3, C10 | 100 nF / 50 V | any SMD 0603 |
| 4 | 6 | C4, C5, C6, C7, C8, C9 | 22 µF / 25 V | any SMD 1206 |
| 5 | 1 | C14 | 100 nF / 630 V | any SMD 1812 |
| 6 | 10 | C15, C16, C17, C18, C19, C20, C21, C26, C27, C28 | 330pF / 25V | any SMD 0603 |
| 7 | 3 | C22, C23, C25 | 1 nF / 25 V | any SMD 0603 |
| 8 | 1 | C24 | 3.3 nF / 25 V | any SMD 0603 |
| 9 | 1 | D1 | FDLL4148 | Fairchild |
| 10 | 2 | D2,D4 | ES1J | Fairchild |
| 11 | 1 | D3 | MM3Z15VB / 200 mW | Fairchild |
| 12 | 1 | D5 | MM3Z12VC / 200 mW | Fairchild |
| 13 | 3 | D7, D8, D9 | RSFJL | TAIWAN SEMICONDUCTOR |
| 14 | 1 | IC1 | FSQ500L | Fairchild |
| 15 | 1 | IC2 | FSB70450 | Fairchild |
| 16 | 1 | J2 | Pin_Header_SMD_2x12 | Wuerth / 6100xx21121 |
| 17 | 1 | LED_15V | LED_0805 | any SMD LED 0805 |
| 18 | 1 | L1 | 1 mH / 0.2A | Wuerth / WE-PD (S) |
| 19 | 1 | Q1 | BC847B | Fairchild |
| 20 | 1 | R1 | 10 K / 0.1 W | any SMD 0603 |
| 21 | 1 | R2 | 1 K / 0.1 W | any SMD 0603 |
| 22 | 1 | R3 | 120R / 0.1 W | any SMD 0603 |
| 23 | 1 | R4 | 680R | any SMD 0805 |
| 24 | 1 | R5 | 1R / 0.1 W | any SMD 0603 |
| 25 | 2 | R6, R10 | 330 K / 0.25 W | any SMD 1206 |
| 26 | 3 | R7, R8, R9 | 15R / 0.125 W | any SMD 0805 |
| 27 | 1 | R11 | 5.6 K / 0.1 W | any SMD 0603 |
| 28 | 9 | R12, R13, R14, R15, R16, R17, R24, R25, R27 | 100R / 0.1 W | any SMD 0603 |
| 29 | 1 | R18 | 4.7 K / 0.1 W | any SMD 0603 |
| 30 | 2 | R19, R20 | n.a. / 0.1 W | any SMD 0603 |
| 31 | 3 | R21, R22, R23 | 0.047R / 0.25 W | any SMD 1206 |
| 32 | 1 | R26 | 2.2K / 0.1 W | any SMD 0603 |
| 33 | 1 | R28 | 0R / 0.125 W | any SMD 0805 |

# 8. Revision History

| Rev. | Date | Description |
|---|---|---|
| 1.0 | Nov, 2014 | Initial Release |
| | | |
| | | |
| | | |

## WARNING AND DISCLAIMER

Replace components on the Evaluation Board only with those parts shown on the parts list (or Bill of Materials) in the Users' Guide. Contact an authorized Fairchild representative with any questions.

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